LOWER CARBONIFEROUS TRILOBITES OF NORTH DEVON AND RELATED SPECIES FROM NORTHERN ENGLAND

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CONTENTS

SYNOPSIS

A systematic description is given of the known Carboniferous trilobites from Devon. *Phillipsia leei*, *Phillibole coddonensis* and *Spatulina spatulata*, originally described by Woodward, are redescribed, together with *Phillibole polleni* and *Diacorphye* ? *vandergrachtii* from northern England. *Macrobole* cf. *brevispina*, *M.* cf. *laticampa*, *Phillibole aprathensis* and *Liobole glabra* previously described from Poland and Germany, are recognized among the specimens from Devon and described. *Phillibole culmica* from Germany is identified with *P. coddonensis*. Three new species, *Waribole chudleighensis*, *Spatulina longispina* and *Typhloproetus cephalispina*, are described.

Five successive trilobite faunas are tentatively recognized in the Devon Carboniferous, and their ages relative to the goniatite time-scale discussed. They are characterized by (i) *Macrobole* aff. *laticampa* (low zone II), (ii) *Spatulina* (II–IIIα), (iii) *Phillibole coddonensis* (IIIα) (iv) *P. aprathensis* (IIIα) and (v) *Phillipsia leei* (IIIβ–IIIγ).

I INTRODUCTION

The Carboniferous trilobites of the British Isles can be divided into two groups, whose distribution appears to be closely linked with lithological facies. On the one hand are the large, robust, thick-shelled and heavily ornamented species, often with large eyes, which are found in the limestones of " reef " and " massif " facies of the Carboniferous limestone. On the other hand, in the radiolarian cherts and shales which characterize the Lower Carboniferous of south-west England is found a different group, which occasionally penetrated northwards in a shale facies to northern England. This latter group comprises generally small forms, their tests

thin and fragile, mostly smooth, and their eyes small or absent. It is reasonable to assume that these represent a hemi-pelagic fauna of the open sea, whilst the former group is part of a shallow water benthos. This account sets out to describe the hemi-pelagic group in detail, and to examine their stratigraphical distribution. In contrast to the " limestone " fauna, which is dominated by the Family Phillipsiidae, the trilobites of south-west England consist largely of members of the Cyrtosymbolinae; the latter sub-family, however, is by no means confined to this facies, and includes many robust and large eyed forms of both Devonian and Carboniferous age.

A reappraisal of the classification of some of these trilobites has been made by Hahn (1965). In his scheme the following species described herein would be classified as follows:

Cyrtosymbole (*Macrobole*) aff. *laticampa* = ? *Carbonocoryphe*
Cyrtosymbole (*Macrobole*) cf. *brevispina* = *Archegonus* (*Phillibole*) *brevispina* group
Cyrtosymbole (*Waribole*) *chudleighensis* = *Archegonus* (*Waribole*)
Phillibole aprathensis, *Phillibole polleni*, *Phillibole coddonensis* } = *Archegonus* (*Phillibole*) *aprathensis* group.

The first detailed descriptions of these trilobites were by Woodward (1884), who erected three new species of *Phillipsia* in an appendix to his monograph of Carboniferous trilobites, thus tacitly commenting upon their separateness. The collections from the radiolarian cherts of Devon by Hinde & Fox (1895) enabled Woodward to indicate the presence of several new forms, and later (1902), using the more extensive collections of the local amateurs J. G. Hamling and A. Coomáraswamy, he was able to give more complete descriptions of these species. In 1909 I. Thomas described comparable faunas from South Devon, but since that time little attention has been paid to these fossils in this country. In the course of major revisions of Upper Palaeozoic trilobites in Germany, R. & E. Richter (1937–1951) described many new genera and species, making comparisons with the specimens described by Woodward. Similar work has been carried out in Czechoslovakia by Přibyl (1950) and Chlupac (1961), and in Poland by Osmólska (1962). The stratigraphical revision of the North Devon succession by J. M. Thomas, E. E. Swarbrick and the writer has established the horizons of the described trilobites more firmly, and has added much new material (see p. 238). In the course of similar studies in the underlying Pilton Beds, Goldring (1955) has drawn stratigraphical conclusions from the comparative work of Richter. The northern representatives of this fauna were described first by Woodward (1894), but since then they have been mentioned only briefly in stratigraphical descriptions in Geological Survey Memoirs (e.g. Calver & Ramsbottom 1962).

When preserved in chert, or in cherty shale, the test of these trilobites is commonly replaced by finely crystalline silica; in consequence the outer lamina of the test adheres firmly to the external mould, and the inner lamina to the internal mould. Thus the external view of the outer lamina is rarely seen. In contrast, specimens preserved in shales are found either as normal internal or external moulds, or with

their dorsal exterior exposed. Thus the mode of preservation can fundamentally alter the appearance of the fossil, and this has given rise to much confusion in the past. Thus the " brim " of the cephalon or pygidium as described by Woodward often proves to be the mould of the ventral doublure. Moreover, there are sometimes structural differences between the outer and inner lamina. In *Phillibole polleni* for example, the outer surface of the glabella is smooth and unfurrowed, while the inner lamina bears strong furrows ; in *Phillipsia leei* the interpleural furrow sof the pygidium are visible on the internal but not on the external lamina. Thus the greatest care is necessary in the examination and description of this material, and comparison with earlier descriptions is by no means easy.

II SYSTEMATIC DESCRIPTIONS

Conventions and abbreviations

The conventions adopted in the systematic descriptions are those used in the Treatise of Invertebrate Palaeontology (Harrington *in* Moore 1959). For description of facial sutures the α–β–γ–δ–ϵ–ω system is adopted from R. & E. Richter (1949 : 68). Lateral glabellar lobes and furrows are numbered from posterior to anterior, 1p being the first anterior to the occipital furrow. The directions sagittal (abbreviated *sag.*), exsagittal (abbreviated *exsag.*) and transversal (abbreviated *tr.*) are indicated where doubt exists of the meaning of width (*W.*) or length (*L.*).

Described material is deposited in museum collections ; these are indicated by the following abbreviations.

BMNH—British Museum (Natural History)
GSM—Geological Survey & Museum
NDA—North Devon Athenaeum, Barnstaple
KCL—King's College, London

Family **PHILLIPSIIDAE** Oehlert 1886 emend. Hupé 1953

Genus ***PHILLIPSIA*** Portlock 1843 emend. Weller 1936

TYPE SPECIES. *Phillipsia kellii* Portlock by subsequent designation, Vogdes 1890.

Phillipsia leei Woodward

(Pl. 1, figs. 1–6 ; Text-fig. 1)

1884 *Phillipsia leei* Woodward : 66–68, pl. 10, figs. 1–4.
1884 *Phillipsia minor* Woodward : 68, pl. 10, figs. 5, 6*a*, *b*, 7, 8*a*.
1884 *Phillipsia cliffordi* Woodward : 69, pl. 10, figs. 8*b*, 9–12.
1884 *Phillipsia articulosa* Woodward : 70, pl. 10, figs. 6*c*, *d*, 13.
1909 *Phillipsia minor* Woodward ; Thomas : 201, pl. 7, fig. 11.
1909 *Phillipsia* cf. *minor* Woodward ; Thomas : 201–2, pl. 8, figs. 12, 13.
1909 *Phillipsia* sp., Thomas : 202, pl. 7, fig. 14.

DIAGNOSIS. Small *Phillipsia* with internal punctation but no external granulation to carapace ; glabellar furrows other than 1p very indistinct or absent ; pygidium with clearly defined border ; pygidial and cephalic borders with longitudinal striations on underside.

Material. The specimens upon which Woodward based his original description was obtained from Waddon Barton Lane, near Chudleigh, Devon by Mr. J. E. Lee. Some of these were presented by Woodward to the British Museum (Natural History) at the time, while others remained in Lee's private collection at Torquay. On Lee's death, his collection was transferred to the British Museum.

Specimen BMNH. In. 58281, figured by Woodward (1884, pl. 10, fig. 2) is here selected as lectotype ; this is one of the few specimens which displays an external view of the external shell-lamina, and includes some attached thoracic segments (Pl. 1, fig. 1). Specimen BMNH. In. 5280, one of the syntypes figured by Woodward (pl. 10, fig. 3) shows additional cephalic features and the internal view of the outer shell-lamina is here illustrated (Pl. 1, fig. 2). Specimen BMNH. In. 58283, figured as *P. cliffordi* by Woodward (1884, pl. 10, fig. 10), here considered to be a synonym of *P. leei*, shows the pygidial characters of the species. *P. articulosa* BMNH. I. 1861 (Woodward, pl. 10, fig. 13) and *P. minor* BMNH. I. 1860 (Woodward, pl. 10, fig. 7*c*) are also considered to be synonyms of *P. leei*. The Waddon Barton material contains, in addition to the type specimens, 6 nearly complete cephala, 7 cranidia, 6 free cheeks, 10 fragments of thorax, and 46 pygidia. In addition two specimens from Waddon Barton are in the Museum of the Geological Survey, where also, those figured by I. Thomas (1909) are preserved. Additional material from North Devon, has been collected by the author and by J. M. Thomas and is preserved at King's College. A further 10 specimens have been found by M. R. House in excavations in Ugbrooke Park, Chudleigh. A single headshield was collected from a comparable horizon in the north-east Rhenish Schiefergebirge by G. Warrington.

Horizon and Localities.

1. Red-stained black cherty shales, associated with *Neoglyphioceras spirale* and *Mesoglyphioceras* aff. *granosus* i.e. P_{1d}—P_2 (Butcher & Hodson 1960) at Waddon Barton Lane, Chudleigh, Devon, in sides of lane leading south from Waddon, one mile east of Chudleigh. Nat. Grid Ref. SX 885793. Also similar shales in various trenches in and around Ugbrooke Park, Chudleigh.

2. White chert : Horizon unknown at Hestow Farm, Ideford, Devon. One mile due south of Ideford, near Chudleigh, Devon. Nat. Grid Ref. SX 888761.

3. Upper Shales and limestones associated with *N. spirale* at Whipcott Quarry, Westleigh, N. Devon. Nat. Grid Ref. ST 075188 (J. M. Thomas collection).

4. Upper Shales and limestones, associated with *Posidonia becheri*. Hole Lake Farm Quarry, Staple Cross, Huntsham, N. Devon. Nat. Grid Ref. ST 022208 (J. M. Thomas collection).

5. Rhenaer Kalk (Bed 23, Meischner 1962) associated with *G. spirale*. Aartalstrasse Adorf-Flechtdorf, north-east Rhenish Schiefergebirge.

Description. Cephalon. Outline nearly semicircular, slightly shorter (sag.) than width (tr.) ; posterior border almost straight. Glabella does not reach anterior margin : outline rounded anteriorly, almost parallel sided but slightly constricted medianly ; maximum width less than half length. Anterior of glabella high and globose, lower posteriorly. Occipital segment of glabella clearly demarcated by deep

occipital furrow which is slightly bent forward centrally ; smoothly rounded, narrow (sag.). 1p furrows very deep, backwardly directed to join occipital furrow at points 1/3 along its length ; cut off high triangular glabellar lobes. 2p furrows very faint or absent. Axial furrow sharp, separating glabella from almost flat fixed cheek. Glabella reaches forward to touch narrow, smooth, raised anterior rim. Facial suture cuts anterior margin at a point (α) immediately in line (exsag.) with the forward projection of the sides of glabella at its minimum width, swings outwards sharply to point β which lies in line (tr.) with the maximum width of the glabella, gently curves round to subparallel, slightly convergent with axial furrow to eye region, which lies in line or immediately posterior of 1p furrows. From posterior of

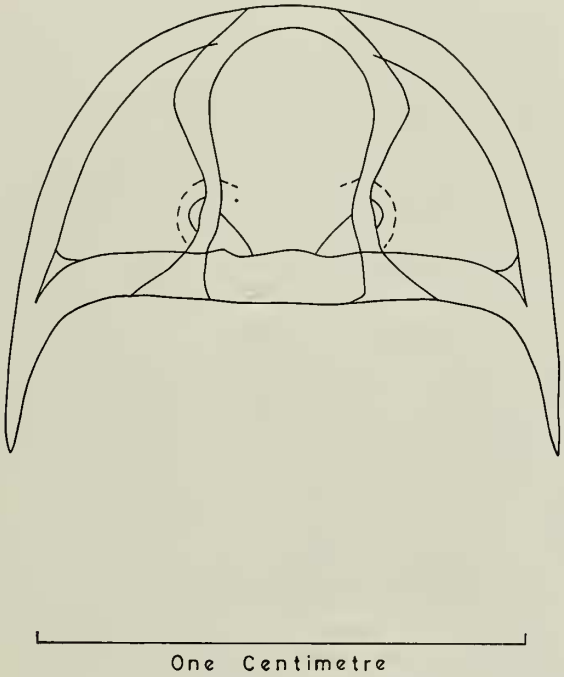


FIG. 1. *Phillipsia leei* Woodward. Reconstruction.

eye (i.e. immediately in front of occipital furrow) swings sharply outwards to cut posterior margin of headshield (ω) a short distance inside angle of genal spine. Thus fixed cheek has sharply pointed triangular extension in occipital region. Eye moderately small, less than $\frac{1}{4}$ length of headshield, reniform, multilensed, situated on a raised platform surrounded by a shallow depression. Free cheek gently inflated, with shallow border furrow and deep pleuroccipital furrow meeting at high angle in genal region. Brim flattened with rounded external margin ; on underside carries fine subparallel longitudinal striae, six or seven laterally, diminishing to 4

anteriorly : 3 or 4 striae continuous with striae on underside of pre-glabellar brim and of genal spine. Spine in direct continuity with cephalic brim ; broadly based tapering evenly to a sharp point ; length variable from less than half to nearly equal to sagittal length of cephalon ; striae on underside externally continuous with those on cephalic brim ; inner striae bend sharply round at genal angle to parallel occipital margin. Whole of interior of cephalon except brim ornamented with a fine indistinct punctation, showing no definite arrangement on cheeks, but a vague alignment into transverse rows on the underside of the glabella. Hypostome has spatulate outline, with strongly elevated median body and flat wings : anterior border convex forward, antero-lateral angles a little more than 90° ; posterior border a smoothly rounded parabola. Median body high, subrectangular outline, touches anterior border.

Thorax. Consists of 9 segments : axis clearly defined, distinctly higher than pleural region ; axis approximately 1/3 width (tr.) of thorax. Axial rings with raised posterior border, sloping forward to a deep straight transverse furrow which divides it from articulating half-ring, which is narrow (sag.) and triangular with a strong rounded ridge anteriorly. Pleural regions moderately flat, pleural segments nearly straight with a broad triangular articulating flange at anterior and distinct posterior ridge. Pleural grooves strong and deep, subcentral, slightly oblique. Pleural extremity truncated, with a short backwardly directed spine.

Pygidium. Outline hemielliptical, somewhat wider (tr.) than long (sag.). Anterior margin nearly straight, inflected forward into a broad triangular flange in the pleural region, deflected slightly forwards in axial region ; antero-lateral angles smoothly rounded. Axis 1/3 or more of width (tr.) anteriorly, tapering rapidly to a smoothly blunt extremity in contact with posterior brim. Axial rings 10 to 14, separated by straight furrows which are quite distinct except at extreme posterior. Axial furrow distinct. Pleural regions flatly arched, with 8–10 clear pleural grooves ; anterior groove is nearly parallel with anterior margin, posterior grooves become increasingly oblique. Pleural ridges strongly asymmetrical, with steep slope facing backwards. Pleural grooves become somewhat fainter posteriorly, but are never effaced ; each groove ends abruptly at the pygidial brim. Interpleural furrows sometimes visible as a faint ridge on the underside of the pygidium, at most over whole length (tr.) of pleural segment anteriorly, but mostly only at extremities of first two or three segments ; at the brim they are sharply deflected backwards. On the internal mould these interpleural furrows make the pleural grooves seem bifid. Pygidium with a narrow brim, without clearly defined furrow on dorsal side. Ventral doublure on underside flat, narrow anteriorly widening rapidly posteriorly, but without trace of mucronation. Underside of brim carries fine slightly irregular subparallel longitudinal striae, 4 or 5 external striae continuous around pygidium ; additional striae, up to 9 in all, inserted at inner side as brim broadens to posterior. Whole underside of pygidium except brim finely punctate. Axial rings have up to 10 moderately large widely spaced punctae along their posterior margins ; in the posterior rings these punctae are anterioposteriorly elongate and occupy the whole axial ring length (sag.). In each pleural segment there are three transverse rows of punctae ; the coarsest are immediately anterior of the intersegmental boundary,

the other two rows are finer, none occurring anterior of the pleural groove. The punctae are fainter in more posterior segments. Appendage muscle scars strongly developed on one specimen (BMNH. In. 55935, Pl. 1, fig. 7) as shallow circular depressions on sides of front five axial rings.

Dimensions (in mm.)

	Cephalon		Pygidium		Axis
BMNH	L. (sag.)	W. (tr.)	L. (sag.)	W. (tr. ant.)	W. axis (tr. ant.)
In. 58281	6·0	11·2			
I. 864	2·4	4·8			
I. 1064		4·5			
I. 1090			5·0	5·5	1·8
I. 1092	5·0				
In. 55902			4·8	3·0	
In. 55903			4·8	7·2	2·1
In. 55914				9·0	3·9
In. 55917			4·0	7·2	2·5
In. 55919			5·3	12·4	3·2
In. 55932	10·3	16·4	9·0	12·5	
In. 55935			8·9	9·9	
In. 55938			4·9	6·0	
GSM 23434			4·0	4·0	

Remarks. Woodward (1884) identified four species from among the Waddon Barton material. In view of the continuity of variation displayed by this assemblage, however, I would regard them as constituting one species. *Phillipsia cliffordi* was distinguished solely on pygidial characters. Woodward appears to have been misled by the different aspects afforded by the internal moulds, and to have given the name *cliffordi* to those moulds which show an apparently broader brim, and in which the traces of the intersegmental boundary give the appearance of bifurcation to the pleural grooves. *P. minor* appears to have been distinguished by the characters of the head-shield, but the differences were not specified. The curvature of the genal spine in pl. 10, fig. 6*a* is, as is apparent from the counterpart (BMNH. I. 1864), due to the superimposition of a thoracic segment upon the genal angle. The original of pl. 10, fig. 7*c* (BMNH. I. 1860) shows that this same feature is a misrepresentation. *P. articulosa* was described as having 17 coalesced segments in the pygidial axis. No specimens in the Lee collection have this number, and indeed the two specimens in figure 6, whose counterpart has been preserved, show the normal 12–13 (as in fact Woodward's figure shows) while the original of figure 13 (BMNH. I. 1861) shows that 3 thoracic segments have been drawn by the artist as part of the pygidium.

I. Thomas (1909) followed Woodward's definitions but suggested that one of his own specimens might be separable as it possesses a strong second pair of glabellar furrows. Examination of the specimen (GSM. 23436) leaves no doubt that these furrows were produced by the crushing of the carapace into the first pair of furrows.

The generic and family affiliations of this species are difficult to determine. This is due partly to the different definitions of the possible groups given by various authors. It would fit within the family Phillipsiidae as defined in the Treatise of Invertebrate Palaeontology (Weller *in* Moore 1959 : 399) except for the absence of more than one pair of glabellar furrows. However, this feature is not regarded as diagnostic by Hupé (1953) whose description in an amended form is purported to have been used in the " Treatise ". Alternatively Hupé does insist that a granular test is characteristic of the family, which the " Treatise " definition does not make essential. Despite these minor points, however, the form of the glabella, the relatively narrow pre-glabellar region, and the multisegmented pygidium, place the species clearly in this family.

The species fits the definitions of the genus *Phillipsia* as emended by Weller (1936 : 704 ; 1959 : 399) except in having a well defined border or flange to the pygidium. In fact, the holotype of *Phillipsia kellii* Portlock 1843 (GSM. 63045) the type species of *Phillipsia* by subsequent designation, does have a quite clearly defined, though narrow, pygidial border. It does, however, possess 3 clearly defined glabellar furrows and a very well-marked surface granulation. Since neither of these characteristics is regarded by Weller (1936, 1959) as diagnostic of the genus, the most satisfactory course seems to be to retain the species *leei* in the genus *Phillipsia*. The present species differs in many ways from the very closely defined generic diagnosis of Reed (1942*b*), who based his definition upon *Asaphus gemmuliferus* of Phillips. Reed's emendation is framed in such detail as to exclude all but the type species and I prefer to follow the less rigidly defined diagnosis of Weller (1959). The two genera *Paladin* Weller 1936 and *Kaskia* Weller 1936 possess similarities to the present species, and have a more clearly defined pygidial border than *Phillipsia kellii*, but both have very large eyes occupying a large area of the free cheek, are strongly granulose externally and have an anterior expansion of the glabella. The species has some characters in common with *Weberides* Reed 1942*b*, notably in the internally striated border to the cephalon and pygidium ; but again the small size of the eyes, and the absence of anterior glabella expansion exclude it from this genus.

Family **PROETIDAE** Salter 1864

Subfamily **CYRTOSYMBOLINAE** Hupé 1953

Genus ***CYRTOSYMBOLE*** R. Richter 1913

Subgenus ***MACROBOLE*** R. & E. Richter 1951

Type species. *Cyrtosymbole* (*Macrobole*) *drewerensis* R. & E. Richter 1951. *Macrobole*, first proposed by R. & E. Richter (1951), has subsequently been given a fuller diagnosis (*in* Moore 1959). Many species of this genus have been described from Germany, Poland and Czechoslovakia, but it is difficult to refer the few specimens from Devon to any of those species which in any case are not mutually comparable.

In view of the paucity of material it has been thought best not to erect new species, but to describe briefly individual specimens and note their affiliations.

The majority of the species belonging to this subgenus are found in Zone I of the Carboniferous, although some range into Zone II. Only if *Phillibole culmica* R. & E. Richter is accepted as a *Macrobole* could the subgenus be said to range into Zone III (see p. 238). In fact it is not easy to draw a line between *Phillibole* and *Macrobole* on cephalic characters, the former seemingly having evolved from the latter : but the strongly segmented tail of *Macrobole* contrasts markedly with that of *Phillibole*.

Cyrtosymbole (*Macrobole*) cf. *brevispina* Osmólska

Pl. 2, figs. 1, 2.

1960 *Cyrtosymbole* (*Waribole*) cf. *aequalis* (Meyer) ; Prentice : 271, pl. 12, fig. 5.
1962 *Cyrtosymbole* (*Macrobole*) cf. *brevispina* Osmólska : 146, pl. 13, fig. 1.

Diagnosis. *Macrobole* with clearly segmented glabella, moderately wide (long.) preglabellar field, pointed anterior margin to cranidium, short pointed genal spine.

Material. The specimen (KCL t182) previously figured by me (Prentice 1960) is presumed to have come from Bed X (see p. 238) at Park Gate Quarry, Tawstock, and consists of a crushed cranidium. Another cranidium from the same quarry (BMNH. I. 3223) contains on the same surface a free cheek presumed to belong to the same individual, together with two free cheeks and a pygidium of *Spatulina spatulata*.

Horizon. Osmólska's specimens came from the upper beds of the *Pericyclus* Zone (i.e. the German zone II) ; while the Tawstock horizon has been correlated by the writer with the boundary of zones II and III α.

Remarks. The broad-based, tapering glabella, with clearly defined occipital furrow and distinct backwardly directed 1p, 2p and 3p glabellar furrows are features which place the North Devon specimens clearly in the *Macrobole* group. The facial suture, expanded widely in front, lying close and parallel to the axial furrow in the palpebral region, and then extending rapidly outwards posteriorly, is also characteristic of the genus. The genera *Waribole* and *Archegonus* (to which the species *aequalis* is now referred) have facial sutures which diverge less abruptly from the axial furrow anteriorly and posteriorly, the eyes and palpebral lobes of *Waribole* are much larger, and the occipital lobe of the glabella is not of equal width throughout. Osmólska noted the presence of an anterior point to the cranidium in larval specimens of *M. brevispina*, but this is not evident in specimens of comparable size to the Devon examples. She does, however, refer to 7 cranidia as " cf. *brevispina* " which attain the length of 2 mm. without losing the anterior spine. The Devon specimens resemble these in their wide preglabellar field, and broadly rounded glabella front.

Cyrtosymbole (Macrobole) aff. *laticampa* Osmolska

Pl. 2, figs. 3, 5.

1962 *Cyrtosymbole* (*Macrobole*) *laticampa* Osmólska : 139, pl. 11, figs. 1–5.
1962 *Cyrtosymbole* (*Macrobole*) ? *laticampa* Osmólska : 141, pl. 11, fig. 7.

Remarks : The specimens found in Devon consist of one cranidium preserved as an internal mould with the internal layer attached (Pl. 2, fig. 3), and its counterpart an external mould with outer layer attached, together with a portion of a cephalon (Pl. 2, fig. 5) which doubtfully belongs to the same species. The cranidium closely resembles *M. laticampa*, especially in having a wide (sag.) preglabellar field ; but this field carries a broad, deep excavation across its anterior which is unknown in *M. laticampa*. The part cephalon is larger than the cranidium, but its deeply lobed glabella and occipital segment of equal width (sag.) place it in *Macrobole* ; it has however a short librigenal spine, whilst that of *M. laticampa* is long.

Both specimens were found in a thin bed of white chert in an old quarry in Claypit Coverts, West Buckland (SS 662291) associated with goniatites of " pericyclid " type. The horizon is estimated to be a few feet above the base of the Chert Formation. *M. laticampa* in Poland is restricted to the *Gattendorfia* Zone (i.e. German zone I), but there is no other evidence to suggest that the Chert Formation begins in this zone : an attribution to zone II is therefore the most likely for this horizon.

Genus **CYRTOSYMBOLE** R. Richter 1913

Subgenus ***WARIBOLE*** R. & E. Richter 1926

Type species. *Cyrtosymbole* (*Waribole*) *warsteinensis* R. & E. Richter 1926.

Cyrtosymbole (Waribole) chudleighensis sp. n.

Pl. 2, fig. 7.

Diagnosis. Minute Cyrtosymboliinids with smooth inflated glabella and widely diverging anterior branches to facial sutures.

Holotype and material. The species is known from one block of specimens only, M. R. House collection 1100, BMNH. It. 1433, from Pit L (of House & Butcher 1962), at the eastern end of the field immediately north-east of Mount Pleasant, Chudleigh, Devon. The block contains abundant fragments of *Posidonia*, and is assigned to the " P " shales of the succession. Four cranidia, with attached and detached thoracic segments, 3 fragments of free cheeks and one pygidium are present all lying within 1 sq. cm. The cranidium figured in Pl. 2, fig. 7*a* is taken as holotype. The two larger free cheeks probably belong to *Phillipsia leei* (see p. 211) which also occurs at this horizon.

Description. Cephalon. Very small size, length (sag.) 1·3, 1·4 and 1·6 mm. Glabella strongly inflated, parallel-sided, with a steep, rounded, blunt anterior extremity. Occipital furrow distinct, strongly curved forward in centre, so that occipital segment is much wider (sag.) in centre than at sides. Occipital segment

same width (tr.) as glabella. Anterior of glabella smoothly rounded and without furrows, 1p furrows shallow, extend diagonally from sides of glabella to join occipital furrow, thus cutting off small triangular lobe. Pre-glabellar field strongly concave, with narrow but distinct enrolled anterior rim. Facial suture cuts anterior border at some distance from the mid-point, then takes an almost semicircular course laterally and posteriorly, swinging inwards to the anterior of palpebral lobe (γ) at a point half way along length (exsag.) of glabella, and close to the axial furrow. From the posterior of the palpebral lobe (ϵ) the suture swings outwards almost parallel with the posterior margin of the cephalon ; i.e. almost along occipital furrow ; then gently back to cut posterior margin at a shallow angle distally. Fixed cheek is thus broad and elliptical in front, very narrow in palpebral region, and produced to a long point occipitally. The concavity of the preglabeller field extends on to the anterior of the fixed cheek, which rises along the sides of the glabella. Palpebral lobe high, crescentic, with two distinct palpebral ridges extending from inner side on to the rising flanks of the glabella immediately in front of the 1p furrow. Free cheek with strong marginal concavity and thin narrow rim. Genal angle probably with short spine.

Thorax. Number of segments unknown. Each segment has high arched axis, slightly less than $\frac{1}{3}$ of the total width of the thorax. Axial furrow deep. Axial ring has deep transverse furrow and an anterior ridge ; articulating half-ring narrow (sag.). Pleural regions shallowly arched, pleural furrows broad and deep. Pleural extremities obscure, perhaps truncate.

Pygidium. Short and subquadrate. Anterior margin strongly curved, with rounded lateral angles. Posterior margin a flattened curve, with a broad concave brim which reduces in width rapidly laterally and anteriorly. Axis short, conical, sharply tapering, with seven axial rings, each with a deep axial furrow. Pleural furrows six, deep and distinct, asymmetrical with steeper slope facing anterior. Anterior furrows reach margin, posterior ones become diagonal and are effaced laterally. Four most anterior interpleural furrows clearly defined.

Discussion. The generic affiliation of this species is problematical. It belongs with the Cyrtosymbolinae rather than the Phillipsiidae because of the presence of a pre-glabellar field, and the small number of segments in the pygidium. It is tentatively placed with the subgenus *Waribole* because it resembles the type-species *W. warsteinensis* in the following features : the possession of a strongly diagonal pair of 1p glabellar furrows, the position of the palpebral lobes, the lateral narrowing of the occipital ring, the short pygidial axis with few segments, and the broad pygidial border. If differs from this species mainly in having a parallel-sided glabella, and in the strongly diverging anterior branches of the suture line. In this latter feature it resembles *Carbonocoryphe* R. & E. Richter, the cranidium figured by R. & E. Richter (1950, pl. 1, fig. 12) as *Carbonocoryphe? ferruginia* showing a somewhat similar wide fixed cheek ; but the pygidial characters of this genus are quite unlike this species. A cranidium described under the name of *Cyrotsymbole librovitchi* var. *latilimbata* by Weber (1937 : 30, text-fig. 15) is very similar, but the associated pygidium has no widened posterior border ; that of *Cyrtosymbole librovitchi* var.

euryaxis (Weber 1937 : 30, text-fig. 14) has the same shape as the present species, but the axis does not taper so strongly. *Phillipsia krasnopolskii* Weber 1937 has some similarities, notably in the brim of the pygidium and the shape of the glabella, but has no pre-glabellar field and 10–11 axial segments in the pygidium.

Genus ***PHILLIBOLE*** R. & E. Richter 1937 : 108

Phillibole aprathensis R. & E. Richter

Pl. 7, figs. 6–9.

1882 *Phillipsia aequalis* Meyer; Kayser: 68, pl. 3, figs. 7, 8.
1882 *Phillipsia* aff. *Eichwaldi* Fischer ; Kayser : 73, pl. 3, fig. 6.
1895 *Phillipsia cliffordi* Woodward ; Woodward : 646, pl. 28, fig. 3*a* only.
1902 *Phillipsia polleni* (?) Woodward : 482, pl. 20, fig. 2, 13 only.
1932 *Cylindraspis aprathensis* R. & E. Richter ; Haubold : 216, 220, 223, 240 (nomen nudum).
1932 *Cylindraspis aprathensis* R. & E. Richter ; Kobold : 484, 508, (nomen nudum).
1937 *Phillibole aprathensis* R. & E. Richter : 109, text-figs. 1, 2.

Diagnosis. *Phillibole* with rounded triangulate headshield : tapering glabella with slight but distinct median constriction ; long, distinctly segmented pygidium with long tapering axis reaching nearly to posterior extremity.

Material. Two cranidia (BMNH. In. 228912, In. 18415) and one pygidium (BMNH In. 18420) from Coddon Hill (SS 5729): cranidia (BMNH. I. 4559, NDA. 807 (Woodward 1902, fig. 13), and NDA 808), free cheek (BMNH. I. 4563) and pygidium (BMNH. In. 18413) from Hannaford Quarry (SS 6029); free cheek (KCL t174) from Templeton Quarry, Tawstock (SS 542297) ; cranidium and counterpart from a loose block above Warrenshill Copse, Bampton (SS 978222) (BMNH It. 1434 *a*, *b*) ; pygidium from Upper half of Chert Beds, Trench Q, Ugbrooke Park, (House coll. 429) ; cranidium and part of thorax (BMNH. I. 1435) Kersdown Beds, Little Holwell Quarry, Bampton (SS 964232).

Horizon. The holotype is from the Posidonien-schiefer (horizon IIIβ) of Aprath (R. & E. Richter 1937). Haubold (1932) records the species in association with *Goniatites intermedius* (IIIα/β) and with *G. falcatus* and *G. waddingtoni* (IIIβ) ; he also records it doubtfully with a IIIγ_2 fauna. Kobold (1932) records the species from IIIγ_1 at Ecksberge in the Harz. However, the associated fauna includes goniatite species subsequently renamed *G. striatus mucronatus* and *G. striatus koboldi* (Pickel 1937 ; Ruprecht 1937), as well as *G. granosum spirale* ; a fauna which was attributed to the IIIβ_7 subzone by Pickel and which compares closely with that of P_{1d} in the British Isles (cf. Hudson & Cotton 1945 : 275). A range from the top of IIIα (= upper P_{1a}) to the base of IIIγ (=P_{1d}—P_{2a}) is thus indicated for this species. This lies within the known stratigraphical range of the Chert Formation in Devon, from which all the specimens are derived. *Ph. aprathensis* has not been found in close association with *Ph. coddonensis* and there is a little evidence to suggest that it may occupy a higher stratigraphical horizon than the latter.

Description of Devonshire material. Glabella long, with broad base, evenly attenuated with slight median constriction ; anterior rounded slightly pointed.

Anterior of glabella higher than posterior. Occipital segment wide (sag.), slightly wider at sides than in centre ; occipital furrow almost straight, distinct. Trace of occipital spine or pustule on centre of occipital segment. Glabellar furrows faint ; 1p curved backwards to cross occipital furrow at less than a third the transverse distance from the sides, then projected straight back across the occipital segment to the posterior margin ; 2p strongly bent back to join 1p, 3p slightly less strongly curved backwards. Axial furrow clear and deep. Preglabellar field narrow and concave, rising gently to an enrolled brim. Fixed cheeks rise from the anterior concavity along sides of glabella, flat behind. Facial suture begins (α) within the projection forward of the axial furrow at the mid-point (exsag.) of the glabella, swings sharply outwards to β, which is rounded and lies behind the line of the glabella anterior; then swings back inwards and from midline of glabella length lies parallel and close to the axial furrow. After crossing the occipital furrow it swings sharply outwards to cut the posterior margin some distance from the axial furrow. Eye lobes very long and very slightly curved, almost impossible to distinguish.

Free cheek gently inflated, with shallow marginal concavity rising to an ill-defined narrow enrolled rim. Pleuroccipital furrow straight, poorly defined; pleuroccipital segment broad, gently inflated, of equal width throughout. Genal angle with small, short, sharply pointed spine. Eye surface comparatively large, inner margin nearly straight, outer margin strongly curved ; surface flat, finely but irregularly reticulate. Ventral doublure broad, curved, with four irregularly spaced parallel striae on the inside.

Thoracic segments with broad axis, clear axial furrow. Pleural sectors with strong median pleural furrow.

Pygidium parabolic in outline ; axis high and distinct, broad at anterior, nearly equal to one-third of the width of the pygidium, rapidly tapering to a moderately blunt extremity a little short of the posterior border. 7 to 10 axial rings, transverse furrows moderately distinct to end of axis. Traces of pygidial appendage muscle scars on the three anterior rings. Pleural regions gently arched, pleural furrows 4 to 6, becoming effaced posteriorly ; strongly oblique, terminating at edge of pleural field. Trace of interpleural furrows on two anterior segments. Border furrow moderately sharp, rim enrolled with roof-shaped cross-section ; faintly longitudinally striate. Post-axial field flat, no post-axial ridge.

Remarks. *Phillibole aprathensis* is a larger trilobite than *Ph. coddenensis* ; it most nearly resembles *Ph. polleni*, from which it may be distinguished by the triangulate form of the headshield, the faint median constriction of the glabella, and the longer pygidial axis. A closely similar form described by Stubblefield (*in* Calver & Ramsbottom 1962) as *Phillobole* aff. *aprathensis* from B_2 horizons in the north of England, differs in having a slightly wider fixed cheek in the post-ocular region.

Phillibole polleni (Woodward)

Pl. 4, figs. 1–4.

1894 *Phillipsia polleni* Woodward : 487, pl. 14, figs. 7–12.
1962 *Phillibole polleni* (Woodward) Calver & Ramsbottom : 180.

DIAGNOSIS. *Phillibole* with nearly semicircular headshield ; gently tapering glabella without median constriction. Pygidial axis with a blunt, rounded extremity which lies some distance in front of posterior border.

LECTOTYPE. BMNH It. 371*a* (figured Woodward, 1894, pl. 14, fig. 9) here selected as lectotype.

MATERIAL. The lectotype and all specimens figured by Woodward are preserved in the British Muscum (Natural History), under registered numbers It. 369–374. All are preserved as slightly flattened carapaces in shale, with the original structure of the outer lamina preserved, or as external moulds of this. The structure of the inner lamina can be rendered visible through the test by wetting the surface.

LOCALITY AND HORIZON : The species is only known from the type locality ; the banks of the River Hodder near Stonyhurst, Lancashire. According to Calver & Ramsbottom (1962 : 180) this horizon lies above the *B. hodderense* Beds, in beds equivalent in age to the Pendleside Limestone. The upper part of this limestone belongs to the B_2 zone, the lower probably to B_1, and *Phillibole* cf. *polleni* has been recorded in association with *Bollandoceras hodderense* (Calver & Ramsbottom 1962 : 311–312) at some Pendleside Limestone localities. It may thus be assumed that the stratigraphical horizon is at or just below the B_1/B_2 zonal boundary (see p. 238).

DESCRIPTION. Carapace moderately large, flatly arched, with a broad, rather prominent axis. Test moderately thin.

DIMENSIONS (in mm.) :

	It. 371	It. 369	It. 370
L. cephalon . . .	9·5	—	7·8
W. cephalon . . .	16·0	—	10·8
L. glabella . . .	6·0	—	
L. pygidium . . .	7·8	5·1	6·2
W. pygidium . . .	14·0	9·8	12·0
W. pyg. axis . . .	6·0		

Cephalon nearly semicircular in outline. Glabella broad at base, tapering forward, front bluntly rounded with axial furrows straight or slightly convex. Occipital segment equal in length sagitally and exsagitally. Occipital furrow nearly straight but composed of three equal, forwardly convex, curves. Anterior of glabella smooth, lateral furrows not visible externally. Internally there are three short, backwardly directed furrows. 1p begins at axial furrow a greater distance in front of occipital segment than the length (sag.) of the latter ; gently curved backwards at first then sharply inclined towards occipital furrow. 2p not so far in front, parallel with lateral part of 1p ; short. 3p closer still, and shorter. Preglabellar field narrow, deeply concave rising to a high, strongly enrolled rim, which bears 3 or 4 subparallel longitudinal striations on its upper surface. Fixed cheeks flat along sides of glabella. Facial suture begins (α) in line with, or slightly wide of, the forward projection of the axial furrows at the base of the glabella ; swings sharply outwards to β, so that α–β is very short ; then back in a smooth outwardly convex curve to very near axial furrow at γ. γ–δ–ϵ is a smooth outwardly convex curve along side of glabella reaching

nearest point to axial furrow just ahead of the pleuroccipital furrow. From here bends sharply outwards across pleuroccipital furrow to cut the posterior margin (ω) at internal angle of genal spine. Fixed cheeks thus widely expanded in front, narrow along sides of glabella, with palpebral lobe situated almost exactly half way along length of cranidium. Pleuroccipital furrow sharp. Posterior margin straight adaxially, laterally bent back into a posteriorly projecting curve.

Free cheeks broad, only slightly inflated, with a broad marginal concavity which rises laterally to a narrow, strongly enrolled rim ; this is broader anteriorly and narrower laterally and carries 3–4 parallel striations. Genal spine very short, sharply pointed ; outer edge in direct continuation of the cephalic curve ; inner edge concave so that posterior margin of the free cheek is deeply notched. Eye platform large, flat, kidney-shaped ; eye with numerous lenses, arranged in two intersecting series concentric upon the anterior point and a point on the inner margin one third eye-length from posterior. Ventral doublure broad, bearing two strong subcentral and several irregular lateral subparallel longitudinal striae, all of which continue on to genal spine. Pleuroccipital furrow clear, dying out laterally ; pleuroccipital segment slightly raised.

Thorax. Consists of 9 segments. Axis broad, considerably broader than pleural fields, gently arched. Axial furrows sharp. Axial ring equal width (sag. and exsag.) across axis ; a deep transverse groove is situated immediately under the posterior margin of the preceding ring ; from this the ring rises flatly to the posterior margin, which is sharply angulate and carries a row of small pustules.

Pleural fields arched a little less than the axis ; pleurae inflected dorsally and posteriorly at the mid-length. Pleural segments of equal width throughout, with a sharp posteriorly-directed point at their extremity. Pleural furrows moderately deep and broad, sub-central ; otherwise the surface of the pleurae are flat, inclined forward beneath the posterior of the preceding segment.

Pygidium. Anterior margin straight in centre, slightly bent back laterally from mid-point of pleural fields ; antero-lateral corners rounded. Posterior outline short shield-shape. Axis broad, rapidly tapering to a raised blunt extremity situated well forward of posterior margin ; axis high, slightly carinate. 10–12 axial furrows on internal lamina, crowded together at posterior : less than this visible externally. Pleural fields gently arched along mid-line. Anterior border has a low but distinct ridge, parallel with the anterior margin adaxially ; but distally from the point of inflection of the border it diverges and diminishes, thus separating off a narrow triangular area antero-laterally. 3–7 pleural furrows visible, becoming increasingly oblique posteriorly ; do not reach border. 3–4 interpleural furrows faintly visible on internal laminae. Rim furrow a gentle concavity, rising to a wide slightly raised, carinate brim.

Remarks. *Phillibole polleni* differs from *P. aprathensis* in having a more nearly semicircular headshield ; in having a more smoothly attenuated (i.e. not medianly constricted) glabellar outline ; and in having a shorter pygidial axis. From *Ph. coddonensis* it differs in its larger size, in the shape of the headshield and in the larger relative size of the pygidium.

Phillibole coddonensis (Woodward)

Pl. 3, figs. 1–5.

1895 *Proetus* sp. *a* & *b* Woodward : 648, pl. 28, figs. 7, 8.
1895 *Phillipsia leei* Woodward ; Woodward : 646, pl. 28, figs. 1, 1*a*.
1902 *Proetus coddonensis* Woodward : 483, pl. 20, figs. 5, 7–11.

Diagnosis. Small *Phillibole* with broad axis ; some glabellar segmentation ; thorax with eight segments ; very short pygidium.

Lectotype. BMNH. I. 4560 (figured Woodward 1902, pl. 20, fig. 8), here selected as lectotype.

Material. The specimens upon which this species was founded were collected from North Devon by Hamling & Coomáráswamy, and were subsequently presented to the British Museum (Natural History). Fourteen others from the same collections are to be found in the North Devon Athenaeum, Barnstaple (NDA 812–816). Additional material has been collected from north-east Devon by J. M. Thomas and from north-west Devon by the present author. The total collection examined comprises 3 complete shields, 11 headshields, 11 cranidia, 8 parts of thorax and 15 pygidia.

Localities and horizon.

1. Coombe (or Combe) Quarry and Wood, Barnstaple. There are a number of old quarries in the neighbourhood of Coombe Wood, which is situated at the eastern end of Codden Hill, 3 miles south-east of Barnstaple, North Devon (Nat. Grid ref. SS 592295). Several of these quarries expose the white chert in which the museum specimens are preserved, but intensive search has failed to yield any more specimens. This group of white cherts occupies a median position in the Chert Formation of the Codden Hill region.

2. Templeton Quarry, Tawstock (Nat. Grid ref. SS 541296). Bed Y, Chert Formation (Prentice 1960).

3. Warrenshill Quarry, Bampton. Bed 16 and 18, Bampton Chert Formation (see p. 238).

4. *Phillibole culmica* regarded as nearly related, was described by R. & E. Richter from the Posidonienschiefer of Aprath, Germany, at an horizon referred to zone III*β*.

Description. Cephalon. Outline semicircular, length (sag.) being almost exactly twice width (tr.). Glabellar outline sometimes almost parallel-sided, but mostly tapered anteriorly ; base is broad and parallel-sided, attenuation begins abruptly about mid-length of glabella, then becomes parallel sided again anteriorly. Anterior end is bluntly rounded ; anterior portion high, spherical, posterior somewhat lower and flatter. Axial furrow distinct. Occipital furrow nearly straight, or forwardly bowed in centre ; occipital segment narrow (sag.) and strongly inflated. 1p furrow very faint to moderately distinct ; begins well forward and is sharply directed backward : in some specimens joins occipital furrow $\frac{1}{4}$ to $\frac{1}{3}$ along its length : in a very few specimens crosses the occipital furrow and curves outwards across occipital segment to reach axial furrow again near posterior border. 2p furrows sometimes absent, sometimes distinct ; begin at the point of glabella attenuation,

and run backwards across glabella more or less parallel to 1p. 3p furrows rarely visible, faint only at sides, directed straight across glabella or slightly forward. Fixed cheek in front of glabella is deeply concave, rising sharply forward to a high enrolled rim ; from this concavity the fixed cheeks rise gently on each side of the glabella, reaching maximum height in the eye region : then fall sharply to occipital furrow. Suture-line begins (α) at point in line with the forward projection of the axial furrows along the sides of the glabella, and swings sharply outwards to β, which lies in the rim furrow in line (exsag.) with or just behind the anterior point of the glabella. Then converges gently with sides of glabella, becoming nearly parallel with these in neighbourhood of 2p furrow. Inflection in eye region very slight. Near to the occipital furrow it swings sharply outwards to cut posterior margin at a point just inside the angle at the base of the spine. Eye small or absent, situated posteriorly of mid-line. Free cheek gently inflated in centre, crossed by strong straight pleuroccipital furrow ; anterior slope of furrow steeper than posterior. Rim furrow broad and deep, rising to flat brim whose edge is sharply enrolled. Doublure broad and flat, carrying 3 or more rows of faint longitudinal striae on underside. Genal spine short, sharply pointed, outer margin deflected slightly outwards.

Thorax. Eight segments only. Axis substantially broader than pleural fields, strongly raised with deep axial furrow. Axial segments W-shaped, especially anteriorly : strongly inflated with a deep transverse furrow at anterior and posterior. Articulating half-ring concealed. Pleural segments broad (exsag.) and short (tr.), sinuous, with rounded truncate extremities. Pleural furrows a deep median excavation, bounded on anterior by strongly diagonal pleural ridge.

Pygidium. Small, narrower than thorax (tr.) at anterior ; short subtriangular in outline. Anterior margin bent forward at axis, but backwards in pleural region. Anterolateral corners rounded. Axis broad anteriorly, broader than pleural region, narrowing rapidly posteriorly to a rounded extremity a short distance anterior of the margin. Faint, low, narrow post-axial ridge rarely developed. Axial rings 5–8, separated by slightly flexuous transverse furrows. First anterior furrow deeper and wider than all others ; posterior furrows diminishing in intensity until posterior extremity is almost smooth. Pleural fields gently raised, indistinct brim furrow and narrow brim with enrolled edge. Pleural furrows 5 to 6, reaching nearly to margin, becoming increasingly oblique and fainter posteriorly. First anterior pleural furrow deeper than others. Interpleural furrows faintly developed laterally only on first 2 to 3 segments. Ventral doublure broad and flat to posterior, narrowing rapidly anteriorly.

Meraspid stage. One specimen and its counterpart (BMNH. In. 22892), collected by Wheelton Hind from Codden Hill, has 5 thoracic segments and clearly represents the meraspid stage. The proportions of the headshield are similar to those of the adult, but the genal spines show a slight outward deflection. There is a slight indication of a pointed anterior margin to the pre-glabellar region. The suture-line has a similar course to the adult, but is proportionately further away from the axial furrow in the median region, and the posterior divergence begins somewhat in front of the occipital furrow. The five thoracic segments are of adult form. The

pygidium is small, and shows a posterior bent downwards. Segmentation of the axis is strong ; four axial rings are clearly defined by deep furrows, which gradually decrease in depth towards the rear. Four pleural furrows, and two interpleural, are visible.

Remarks : The similarity between *P. coddonensis* and *P. culmica* was acknowledged by R. & E. Richter (1939 : 110), but they maintained the identity of the latter on the grounds that *P. coddonensis* has a less-diminishing glabella, and a tail with a well developed brim. The former feature is somewhat variable in *P. coddonensis*, but in the material examined there are many specimens which can be matched in this feature with Richter's illustrations of *P. culmica*. Photographs of the holotype of *P. culmica* (kindly supplied by Dr. G. Hahn) show however that these specimens have a longer and more elliptical headshield, a more strongly attenuated glabella, and a narrower (tr.) posterior section of the fixed cheek than *P. coddonensis*. The appearance of a brim to the tail in Woodward's illustrations is seemingly due to the preservation as a mould, which leave a space between the inner and outer moulds of the edge of the doublure. In reality *P. coddonensis* has no more brim than *P. culmica*.

Osmólska (1962 : 75) has referred *P. culmica* to the subgenus *Macrobole*. The present species resembles *M. drewerensis* (the type species) in the lobation of the glabella, but the strong segmentation of the pygidium in *Macrobole* is a major point of distinction. The pygidium of *P. coddonensis*, while unlike that of almost any other contemporary trilobite in form, does have the accentuated anterior furrow and the rather indistinct pleural furrows of *Phillibole*. The outline of the glabella and the course of the suture line are similar to those of *Phillibole aprathensis* (the type species), but *coddonensis* is distinguished by the presence of glabellar segmentation. It should be borne in mind, however, that in some species of *Phillibole* (e.g. *P. polleni* see p. 221) the glabella is smooth on the outer, and segmented on the inner lamina. Since the type material of *P. aprathensis* is preserved in shale, the holotype presumably preserves the outer lamina, while all the material of *P. coddonensis* consists of moulds of the inner. The presence of only eight thoracic segments, the breadth of the axis and the very small pygidium distinguish this species from all other species of *Phillibole*.

Dimensions (in mm.)

Cephalon :

	L. (sag.)	W. (tr.)	Lg. (sag.)	Wg. (tr.)	L. (genal spine)
BMNH.					
I. 4560	3·8	5·8	3·0	2·0	1·0
I. 4561	4·9	8·1	4·2	3·5	0·9
I. 4564	4·2	11·5	2·8	—	—
I. 4565	4·0	9·0	3·5	3·1	—
I. 4571	4·0	5·8	—	2·0	1·0
KCL.					
t. 170	3·6	5·0	—	—	0·9
t. 191	4·8	—	3·4	2·2	0·9

Thorax :

	L. (sag.)	W. (tr.)	W. ax. (tr.)
BMNH. I. 4560	3·0	4·8	2·1 ant. 1·6 post.

Pygidium :

	L. (sag.)	W. (tr.)	L. ax. (sag.)	W. ax. (tr. ant.)
BMNH.				
I. 4560	1·8	3·8	1·6	1·2
I. 4564	2·3	6·1	1·8	2·7
In. 18409	2·1	5·0	1·5	2·0
KCL.				
t. 188	3·3	6·1	—	—
t. 208	3·6	4·4	—	—

Genus ***LIOBOLE*** R. & E. Richter 1949

The genus *Liobole* was proposed as a subgenus of *Phillibole* by R. & E. Richter (1949 : 71) with *Phillipsia glabra* Holzapfel 1889 as type species. The name was later raised to generic rank by R. & E. Richter (e.g. 1951 : 231), Struve (*in* Moore 1959) and Osmólska (1962). The *Liobole* group seems more closely linked with the genus *Liobolina* (see Osmólska 1962 : 76, 92) than with *Phillibole* s.s., so that its generic rank seems to be substantiated.

Liobole glabra (Holzapfel)

Pl. 3, figs. 1–5.

1889 *Phillipsia glabra* Holzapfel : 73, pl. 8, fig. 23.
1895 *Griffithides acanthiceps* Woodward : 674, pl. 28, figs. 5, 5*a*.
1902 *Phillipsia* sp. Woodward : 482.
1902 *Proetus* sp. Woodward : 484, pl. 20, fig. 1.
1949 *Phillibole* (*Liobole*) *glabra glabra* (Holzapfel) ; R. & E. Richter : 72, pl. 1, figs. 1–3.
1949 *Phillibole* (*Liobole*) *glabra hiemalis* R. & E. Richter : 74, pl. 1, figs. 4–11, (subsp. n.).
1960 *Phillibole* (*Liobole*) *glabra glabra* (Holzapfel) ; Prentice : 271, pl. 12, fig. 1.

Diagnosis. As for R. & E. Richter 1949 : 72.

Material. Three cranidia (BMNH. It. 381, It. 1436, It. 1437*a*, *b*, KCL t175–6) one with thoracic segments and a fragment of free cheek attached, both somewhat crushed. One specimen (NDA 822 and counterpart BMNH. In. 33775) with thoracic segments and slightly displaced pygidium : three separate pygidia (BMNH. I. 1438, I. 4562, In. 18411). Two separate free cheeks and counterparts (BMNH. I. 3020, I. 3216).

Localities and horizon.

1. Park Gate Quarry, Tawstock. Nat. Grid ref. SS 555297. Probably from Bed X, correlated (Prentice 1960 : 273) with zone II/IIIα, at a low horizon within the Codden Hill facies of the Chert Formation.

2. Codden Hill ; Hannaford Quarry ; Templeton Quarry, Tawstock. All these localities lie within the Codden Hill Cherts, but the last-named locality is doubtful, as all other fossils collected from this quarry belong to a higher horizon.

3. Warrenshill Quarry, east of Bampton, North Devon (Nat. Grid ref. SS 978222), Bed 15, Bampton Chert beds (see p. 238), J. M. Thomas collection.

Description of North Devon material.

Cephalon. Outline probably semicircular, shorter (sag.) than wide (tr.) Glabellar outline broad, attenuated forward, anterior end almost semicircular in plan. Posterior margin of glabella convex forward, so that occipital segment is very narrow (sag.) in centre ; this margin has a sharp raised rim. Occipital glabellar furrow distinct and deep in central third, branches laterally ; posterior branch fades away rapidly, anterior branch (1p) runs forward and nearly reaches axial furrow. These two branches enclose a lobe which is pear-shaped in outline, moderately raised laterally. At the posterior margin of the occipital segment is a deep furrow bounded posteriorly by a very narrow posterior rim ; this furrow meets the axial furrow and the posterior fixigenal furrow at a deep triangular apodemal pit. Second glabellar furrow (2p) starts at or near the axial furrow, runs gently backwards and deepens, then swings sharply backwards to join 1p and occipital furrows at their point of divergence, becoming fainter as it does so. Third furrow (3p) faint, nearly parallel with 2p but confined to sides of glabella and shows no backward swing. Axial furrow clear but not deep. Preglabellar field narrow, concave, rising steeply to a sharply enrolled rim higher than the glabella. Anterior doublure broad, carries four parallel longitudinal striae on inner side. Anterior of fixed cheek faintly concave in continuity with concavity of preglabellar field, then rises until nearly flat along sides of glabella : rises again slightly just in front of pleuroccipital furrow. Pleuroccipital furrow broad and deep, widens laterally ; anterior slope steeper than posterior ; course straight. Occipital segment of fixed cheek very narrow, inflated, bounded posteriorly by very deep furrow. Facial suture begins (α) close to mid line, cuts very obliquely across border in an almost straight line to β, which lies only just behind the line of the anterior of the glabella. From β, which is gently rounded, suture curves inwards to within a short distance of the axial furrow. There is a shallow palpebral lobe ($\gamma - \epsilon$) situated well forward ; from ϵ suture diverges in a gentle outwardly concave curve to cross occipital furrow and reach ω wide of the axial region. Posterior part of the fixed cheek is thus broadly triangular in shape.

Free cheek gently, flatly inflated. Margin broad, gently raised, with a very indistinct border furrow ; genal angle rounded, produced into short, spatulate extension. Pleuroccipital furrow sharp near axis, dies out abruptly at border furrow. Eye visible on inner test lamina only, no corresponding impression on inside of outer laminae, nor presumably on dorsal exterior. Eye platform very slightly raised, situated well forward near the border furrow. Inner side of eye practically straight, outer side strongly convex, so that eye is nearly semi-circular ; surface finely reticulate, composed of two series of intersecting concentric ridges, centred at points $\frac{1}{4}$ and $\frac{3}{4}$ along inner border of eye ; each interspace so formed bears a central circular depression. Doublure of the free cheeks broad, strongly enrolled, diminishing in

width posteriorly. Inside of doublure carries fine sub-parallel striations, which are not present on the underside of the dorsal margin.

Thorax. Axis broad, equal in width or somewhat wider than the pleural regions ; somewhat more raised than pleurae. Axial ring shows a strong transverse concavity ; anterior is a low ridge higher along median line than laterally, where it is largely covered by the posterior of the preceding ring. The concavity is steeper on its anterior side ; behind, it rises gently to a high transverse ridge, which terminates at each end in a boss at the axial furrow. Beneath this posterior ridge in the median line the carapace is deeply infolded ; laterally this fold opens out so that the ring shows a posterior sulcus bounded behind by a low triangular flange. The posterior margin of this flange is continuous with the posterior margin of the pleural segments. Pleural segments are flatly arched, nearly straight with blunt rounded extremities ; each has a transverse concavity bounded by a high posterior ridge ; the concavity shallows laterally and is crossed by an oblique ridge which commences anteriorly near the axial furrow and terminates near the posterior side at the pleural extremities. This ridge is steeper on its posterior side, and slightly lower laterally than near the axis.

The maximum number of segments found articulated is eight.

Pygidium. Shield-shaped in outline, somewhat wider than long. Anterior margin bowed forward in axial region, gently bowed backwards in pleural ; antero-lateral angles rounded. Axis moderately broad, slightly wider than pleural region at pygidial anterior ; axial furrows straight, so that axis is regularly tapering ; axial furrows and identity of axis become less pronounced posteriorly. Axis terminates abruptly at a rounded extremity before reaching posterior margin, continues as a very low postaxial ridge. Anterior of axis bears a deep, forwardly convex, transverse furrow, which separates off a high, narrow, anterior axial ring. Axial rings faint, up to 12 sometimes faintly visible. Paired pygidial muscle apodemes visible on internal mould at ends on first 6 transverse furrows. Pleural regions gently inflated, nearly smooth. Anterior has a deep transverse furrow, bounded by a high, narrow, anterior ridge ; this furrow lies parallel with the anterior border from axis to midpleural (tr.) region, then swings sharply backwards, so that antero-lateral corner is a narrow triangular flange. Posterior pleural furrows very faint (9+), separated by equally faint interpleural furrows ; both sets are just visible laterally as far as the border furrow. Border furrow faint, accentuated by crushing, separating a moderately broad flat brim. Ventral doublure broad, strongly enrolled, slightly wider at posterior extremity ; bears faint traces of internal longitudinal striation.

Remarks. The features which distinguish the subspecies *L. glabra glabra* and *L. glabra hiemalis* (R. & E. Richter 1949) are unfortunately most susceptible to modification by crushing and distortion. It has been thought advisable therefore to refer the North Devon specimens only to the species without attempting further subdivision. They are distinguished (*a*) from *L. coalescens* R. & E. Richter by the much clearer development of " occipital-solution " and the more clearly defined axial region, (*b*) from *L. glabroides* R. & E. Richter by the broader and less attenuat-

ing glabella, and by the broadly triangulate free cheeks, (*c*) from *L. subaequalis* (Holzapfel) by the furrowed glabella and (*d*) from *L. zarembiensis* Osmólska by the narrower free cheeks.

Thoracic segments have rarely been described in the Cyrtosymbolids, and never previously for a species of *Liobole*. There is a tendency for the ventral anterior doublure to adhere to the free cheek when this is separated from the cranidium ; this gives the appearance of a short spatulate " genal spine ", and resulted in Woodward (1895, text-fig. 5) illustrating a specimen in an inverted position. The present account shows that *L. glabra* has a rounded, slightly extended genal angle similar to other members of the genus (e.g. *L. subaequalis* Holzapfel).

Genus ***SPATULINA*** Osmólska 1962

Type species. *Phillipsia spatulata* Woodward 1902.

The genus *Spatulina* with *S. spatulata* as type species, includes also *Phillibole*? (*Cystispina*) *nasifrons* R. & E. Richter 1949 and *Phillibole* (? *Cystispina*) sp. nov. Prentice 1960 (Osmólska 1962 : 74, 90, 180–181).

Emended diagnosis. Cyrtosymbolids with stout, hollow, genal spines. Cylindrical glabella with moderately distinct or faint dorsal furrows. Occipital glabellar segment of equal length sagitally and exsagitally, occipital furrow complete and unbranched. Fixigenae very narrow, with an abrupt forward slope anteriorly (based on diagnosis by Osmólska 1962 : 180).

Osmólska suggests that the resemblances of this group of *Cystispina*, in which *S. spatulata* was formerly placed by R. & E. Richter, are merely superficial, and that the cranidial structure marks them out distinctively from that genus. Certainly the three known species of *Spatulina* have very similar cephala, the only points of distinction being the shape of the librigenal spines, and slight differences in the shape of the glabella. The thorax is known only in *S. longispina* sp. nov., in which it consists of 9 segments. The pygidium is known from all three species, and is, characteristically, nearly smooth, with a high tapering axis terminating some distance in front of the posterior extremity, which falls away rapidly from the tip of the axis. The pleural fields have only a very narrow indistinct rim.

This small, closely knit group, has a very restricted range geographically and stratigraphically. It is known only from the Chert Formation of North Devon, and from the Erdbach & Belecke limestones in the Rhineland ; *Pericyclus* Zone (II).

Spatulina spatulata (Woodward)

Pl. 6, figs. 5, 6, Text-fig. 2.

1902 *Phillipsia spatulata* Woodward : 482, pl. 20, figs. 3, 4.
1939 *Phillibole* ? (*Cystispina*) *spatulata* (Woodward) R. & E. Richter : 107, text-figs. 17, 18.
1960 *Phillibole* ? (*Cystispina*) *spatulata* (Woodward) ; Prentice : 271, pl. 12, fig. 9.
1962 *Cystispina spatulata* (Woodward) ; Osmólska : 180.

Diagnosis. *Spatulina* with short, bluntly rounded, hollow spines. Glabella parallel-sided.

LECTOTYPE. BMNH. I. 3215 selected by R. & E. Richter (1939) from among the syntype material cited but not figured by Woodward (1902).

MATERIAL. In addition to the lectotype three specimens described by Woodward are preserved in the British Museum (Natural History): I. 4572 (Woodward 1902, pl. 20, fig. 4), I. 3219 and I. 3223. Other specimens from the Woodward collection are in the North Devon Athenaeum : NDA 802, the original of pl. 20, fig. 3 and its counterpart NDA 803, NDA 804–805. Additional material collected by the writer is now in the British Museum (Natural History) nos. BNMH. It. 1439*a*, *b*.

LOCALITY AND HORIZON. The species is only known from the Chert Formation of Codden Hill, Combe Wood and Tawstock, Barnstaple, North Devon. Specimens BMNH. It. 1439*a*, *b* and I. 3223 came from Park Gate Quarry, Tawstock, where Bed X, of Zone II/IIIα age is exposed (see p. 238) ; on the latter specimen also occurs *Macrobole* cf. *brevispina* (see p. 238) indicating a Zone II horizon.

DESCRIPTION. A full description was given by R. & E. Richter (1939 : 108) ; the following are additional features seen on the new material:

Occipital segment, which is nearly parallel sided transversely, sometimes carries a small median tubercle ; occipital furrow a little fainter medianly than at sides. Lateral glabella furrows distinct on internal mould ; pre-occipital lobe long (exs.), triangular. Preoccipital (1p) furrow begins at axial furrow, curves gently back, then more sharply to terminate abruptly close in front of occipital furrow. 2p lobe narrower than 1p, 2p furrow parallel to 1p ; 3p furrow faint, parallel to 2p but shorter. 2p furrow begins at axial furrow at point almost halfway along (exs.) the glabella length.

Pregabellar border has 2 or more fine longitudinal striae on inner side. Fixed cheeks have a gentle anterior concavity, rising along the sides of the glabella to the highest point near the 2p furrow ; posterior falls again to pleuroccipital furrow.

Free cheek gently inflated in centre ; an obscure concavity in front deepens to become a moderately deep rim furrow posteriorly. Pleuroccipital furrow distinct, meets rim-furrow at 90°, and the two are produced for a short distance along the dorsal face of the genal spine. Rim of free cheek slightly raised, margin sharply geniculate, so that exterior of free cheek is flattened flange, which continues on to outside of genal spine. Doublure broad, strongly enrolled, with 7–8 subparallel longitudinal striations on the inside of the lower fold.

Genal spine short, approximately half length of cephalon (sag.) ; outer lateral side of spine flattened, in continuity with flattening of the side of the cephalon. Spine at genal angle nearly circular in cross-section ; medianly is slightly inflated and terminates sharply in a slightly mucronate chisel-shaped end, whose edge lies nearly vertically to the plane of the dorsal shield. Dorsal surface of spine gently rounded, impressed for a short distance by the continuation of the coalesced marginal and pleuroccipital furrow ; falls slightly at point. Interior of spine bears fine longitudinal striae in continuity with those of the interior of the doublure.

Thoracic segments unknown.

Pygidium shorter than wide, shield-shaped. Anterior margin has a narrow raised rim ; antero-lateral angles rounded. Axis strongly raised, rapidly tapering,

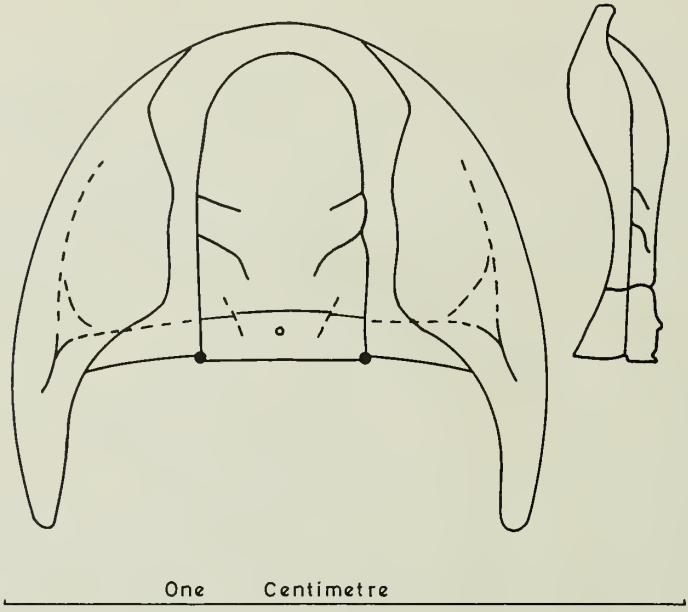


FIG. 2. *Spatulina spatulata* (Woodward). Reconstruction.

terminating in a high, blunt, rounded end. Axial furrow distinct. 8 or more faintly defined axial rings, bearing faint traces of interior of paired pygidial muscle impressions. Pleural regions gently inflated, fall away rapidly behind ; narrow, gently raised rim with an indistinct border furrow. Pleural furrows very faint.

REMARKS. As indicated by Osmólska (1962 : 180) the differences between *S. spatulata* and *Cystispina cystispina* are sufficient to warrant their generic separation. These differences are in the shortness of the preglabellar field, the non-tapering glabella, and the narrow fixigenae in *S. spatulata*. On the other hand, the distinctness of the glabellar furrows is not a point of difference, as in both genera these are clear on the internal mould and indistinct on the interior (and presumably on the dorsal exterior) of the carapace. The pygidia of the two genera are also very similar. From *S. longispina* sp. nov. (see below) *S. spatulata* differs in the shape of its spines and its parallel-sided glabella ; from *S. nasifrons* (R. & E. Richter 1949) it differs in that the latter species has a more prominent, slightly constricted glabella and (*fide* Osmólska 1962 : 180, text-fig. 5*f*) a very broad spine.

Spatulina longispina sp. nov.

Pl. 6, figs. 1–4 ; Text-fig. 3.

1895 *Griffithides longispinus* Portlock ; Woodward : 647, pl. 28, fig. 6.
1960 *Phillibole* (? *Cystispina*) sp. nov. Prentice : 271, pl. 12, fig. 2.

DIAGNOSIS. Moderately large *Spatulina* with long, hollow, pointed librigenal spines. Glabella slightly tapering.

Holotype. One nearly complete specimen, a somewhat crushed internal mould (BMNH. It. 1440*a*) from Park Gate Quarry, Tawstock, North Devon.

Material. Holotype and counterpart (BMNH. It. 1440*b*) : two separated free cheeks, one pygidium and other fragments on a single slab (BMNH. It. 1441): a nearly complete specimen with crushed cranidium and displaced free cheeks (BMNH. I. 4573*a*) and partial counterpart (BMNH. I. 4573*b*) : parts of cephala (NDA. 809, NDA. 825).

Locality and Horizon. The specimens (KCL 170–178, BMNH. It. 1440–41) collected by the author are from Bed X in Park Gate Quarry, Tawstock (see p. 238), of II–IIIα zone age. Specimen BMNH. I. 4573 came from the Chert Formation, Coddon Hill, and those in the North Devon Athenaeum are from Combe Wood and Hannaford from similar horizons.

Description. Cephalon. Outline, when restored, nearly semicircular ; length (sag.) of holotype 11·1 cms., width at occipital region 15·2 cms. Glabella tapers slightly forward, slightly constricted medianly, with oval rounded anterior, moderately high. Occipital furrow clear and nearly straight, continuous across cephalon, tripartite, occipital segment same width (sag.) throughout. No median occipital spine. Axial furrow distinct, glabella raised above fixed cheeks. Preoccipital lobe only slightly longer than occipital segment. 1p glabellar furrows very vague, directed backwards to the mid-point of the occipital furrow. Pre-glabellar field very narrow, upwardly inclined then bent over to form a very narrow brim. This brim continues along the anterior margin of the fixed cheeks, where a deep concavity is continuous with the concavity of the preglabellar field. Facial sutures begin (α) at a point within the projection of the axial furrow at the glabellar sides then swing outwards very obliquely across the brim to β, thence curve inwards to γ which lies close to the axial furrow about half way along (exsag.) the glabella. Palpebral lobes not evident ; suture line follows axial furrow for short distance, then swings outwards gently to ω, which lies near to the internal angle of the genal spine.

Free cheeks nearly flat except for narrow brim ; occipital furrow clear becoming fainter laterally. Genal angle with long spine (7·5 mm. in holotype) circular in cross section for most of its length, then narrowing rapidly to a slightly mucronate point. Anteriorly the dorsal face of the spine bears a deep triangulate concavity, the continuation of the occipital furrow. The spine is hollow with faint internal longitudinal striations. Doublure broad, hollow, in continuity with genal spine ; carries 4 to 5 longitudinal striations on its underside.

Thorax. The remains of only 4 segments are preserved in the holotype, but the specimen figured by Woodward (BMNH. I. 4573*a*) is complete and shows 9 segments. The axis is wide (4·5 mm. in holotype) slightly wider than original to width of the pleurae, moderately raised. Axial ring has deep transverse furrow slightly anterior of the median (sag.) line ; anteriorly a narrow, posteriorly a broad, raised rim. Pleural regions less raised than axis, with broad shallow pleural furrow, and bluntly rounded pleural extremities.

Pygidium. Elongate, hemi-elliptical in outline, with strongly raised, tapering, axis separated from somewhat flatter pleural fields by a sharp axial furrow. Length

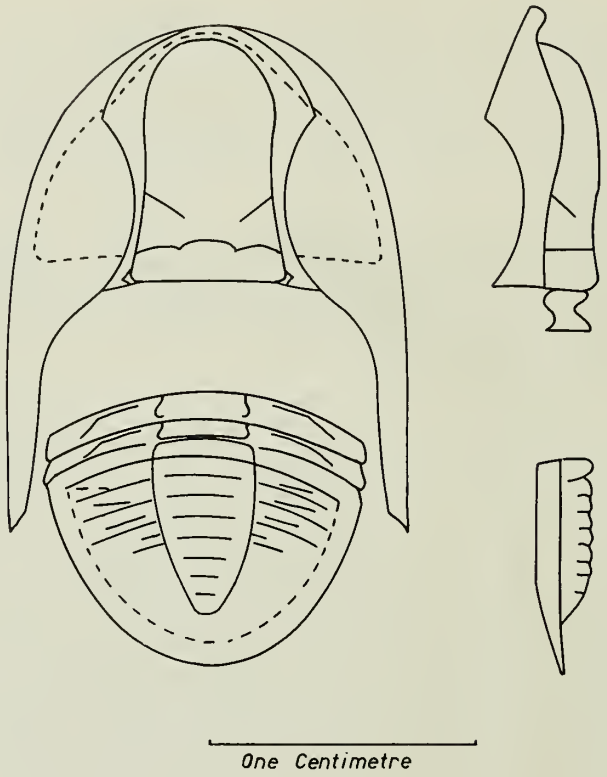


FIG. 3. *Spatulina longispina* sp.n. Reconstruction.

(holotype) 9·9 mm. (sag.), width at anterior border 11·9 mm. (tr.), width of axis 4·5 mm. Axis rapidly tapers to a sharply rounded, strongly elevated point, which lies a short distance (2 mm. in holotype) in front of the posterior of the pygidium. Axial rings 9–11, clearly defined at anterior becoming effaced behind. Pleural fields nearly flat, with traces of four oblique pleural furrows and three interpleural furrows anteriorly. Margin gently raised, no border furrow. Doublure sharply infolded, 1 mm. wide, with faint longitudinal striae internally.

REMARKS: The species may be distinguished from *S. spatulina* by its long, cylindrical, pointed spines, by its slightly tapering glabella with very faint lateral furrows, and by the more distinct segmentation of the pygidium. These same characters distinguish it from *S. nasifrons* (R. & E. Richter).

Specimen BMNH. I. 4573 was assigned by Woodward to *Griffithides longispinus* Portlock. However, the large eyes and the absence of a pre-glabellar field in Portlock's species preclude the inclusion of the present specimens. The trivial name *longispinus* is, nevertheless, apt, and is employed here.

Genus *TYPHLOPROETUS* R. Richter 1913

TYPE SPECIES. *Typhloproetus microdiscus* R. Richter, 1931.

This genus includes 14 species ranging in age from the Middle Famennian to the Lower Visean. They have in common a tapering glabella, anteriorly divergent often ankylosed sutures, vestigial eyes and a characteristically laterally narrowed occipital glabellar segment.

Typhloproetus cephalispina sp. nov.

Pl. 2, figs. 4, 6.

DIAGNOSIS. Typhloproetids with nearly semicircular cephalon, bearing a short spine at anterior extremity. Glabella with one pair of lateral furrows; eyes vestigial. Suture line cuts anterior border near midline, anterior part widely divergent.

HOLOTYPE. Cephalon, BMNH. It. 1442 (J. M. Thomas coll.), Bed 18, Chert Formation, Warrenshill Quarry, Bampton, North Devon (see p. 238).

MATERIAL. In addition to the holotype, one other cephalon with counterpart showing three thoracic segments attached (BMNH. It. 1443*a*, *b*) from same horizon and locality.

HORIZON. Upper Visean, Zone IIIβ.

DESCRIPTION. Cephalon semicircular in outline; holotype length (sag.) 2·0 mm., width 4·0 mm. Glabella broad and flat posteriorly, moderately high and rounded anteriorly; width (holotype) at occipital segment 1·6 mm.; length (sag.) 1·9 mm. Axial furrow clear anteriorly, faint posteriorly. Glabellar outline gently tapering, with strongly rounded anterior; constricted medianly. Occipital furrow deep, the anterior slope being especially steep, curved forward in centre. Occipital segment narrows laterally; strongly inflated with a steep posterior rim. 1p lateral furrows distinct, begin at axial furrow far forward, and are strongly inclined backwards towards, though not reaching, the mid-point of the occipital furrow. Preoccipital lobes are thus long and triangular. In front of 1p furrows glabella is strongly inflated, pyriform. Narrow preglabellar field, strongly concave, rising to a high anterior rim, in centre of which is a short, bluntly rounded cephalic spine, directed upwards and forwards. Fixed cheeks rise from their anterior concavity to faint palpebral lobes situated parallel with mid-line (sag.) of glabella. Posterior of fixed cheek deeply incised by occipital furrow.

Suture line ill-defined, probably ankylosed. Cuts anterior margin (α) very near to centre of cephalic anterior, swings outwards very obliquely to β which lies in the border furrow; then curves in broad curve to near axial furrow near 1p lateral furrow; subparallel to axial furrow for a short distance posteriorly, then diverges in pleuroccipital region to cut posterior margin of headshield at a point (ω) midway between axial furrow and lateral margin of headshield.

Free cheek gently inflated centrally, falling to a broad marginal concavity anteriorly and laterally and steeply to a straight pleuroccipital furrow behind. Eye

platform, small, raised, elongate, situated a little in front of the mid-line (sag.). Rim of cephalon sharply upturned, folded over to a wide doublure which carries 3 subparallel longitudinal striations on the underside. Small pointed genal spine.

Thorax with broad axis, more than a third of the width (tr.) of the carapace. Axial ring high, strongly curved sagitally with a deep anterior transverse furrow separating the articulating half-ring. Pleural regions gently inflated, with their lateral extremities bent sharply ventrally. Pleural furrows deep and wide, extending subcentrally the whole length of the pleurae.

Pygidium unknown.

Remarks. The species is included in *Typhloproetus* on the basis of the form and nature of the facial sutures, the vestigial eyes, and the shape of the occipital glabella segment. It differs from the genotype, *T. microdiscus* in its more prominent glabella, its more widely divergent facial sutures, and the shorter cephalic outline. From *T. dietzi* R. & E. Richter it differs in having a less tapering glabella, and a narrower anterior rim. Neither of these species has a procranidial spine. *T. koslowskii* Osmólska, and ? *T. angustigenalis* Osmólska (which shows some indication of an anterior point) have more elongate glabellae than the present species.

Genus ***DIACORYPHE*** R. & E. Richter 1951

The genus *Diacoryphe* with type-species *D. pfeifferi* includes also *D. gloriola* Richter : both are from the Zone I horizon of Germany (R. & E. Richter 1951 : 252). Osmólska (1962 : 177) included a new species *strenuispina* in this genus on the basis of cranidial similarities, although the thick librigenal spine and strong anterior border would exlude it from the generic diagnosis of R. & E. Richter. The British species *vandergrachtii* has many similarities to *strenuispina*, but differs even more from the type species of *Diacoryphe*. It is therefore, only doubtfully assigned to this genus.

Diacoryphe? vandergrachtii (Woodward)

Pl. 7, figs. 1–5 ; Text-fig. 4.

1894 *Phillipsia van-der-Grachtii* Woodward : 485, pl. 14, figs. 1–6.

Diagnosis. Small trilobites possessing a pyriform glabella with effaced axial furrow at posterior ; strong anterior border-ridge ; long inflated genal spines ; thorax with 8 segments ; and strongly segmented pygidium.

Material. The six specimens described and figured by Woodward (1894) are preserved in the British Museum (Natural History). The specimen figured by Woodward (1894, pl. 14, fig. 3) is here selected as lectotype. The specimens are preserved in shale, either as crushed carapaces showing the external view of the dorsal side, or as external moulds of the same. The specimens were collected from the same locality as those of *Phillibole polleni*, whose stratigraphical horizon (see p. 238) is at or just below the B_1—B_2 zonal boundary.

Description. Outline of carapace elliptical, nearly twice as long as wide. Cephalic outline parabolic, widest at posterior margin, wider than long. Glabella sharply demarcated from fixed cheek anteriorly, but posteriorly the axial furrow is poorly defined. Anterior of glabella rounded, widest (tr.) part $\frac{1}{3}$ of length (sag.) from anterior; behind this gently narrowing to a minimum width (tr.) at the occipital furrow. Occipital lobe of glabella widens again to attain width of the anterior. Occipital furrow faint but continuous across glabella, bent forward in centre; no trace of other furrows. Preglabellar field narrow, rising rapidly to a broad enrolled rim, which carries three longitudinal subparallel ridges. Facial suture cuts anterior margin at a point (α) just inside the forward projection of the widest part of the glabella; from thence it swings sharply outwards to β which lies almost within the marginal furrow. Swings inwards more sharply to γ, which is broadly rounded and lies very close to the axial furrow at the point of maximum glabellar width. From γ the suture is gently convex outwards swinging inward and near to the axial furrow at ϵ, which lies just in front of the occipital furrow. On crossing the occipital furrow the suture line runs sharply outwards in a straight line, to cut the posterior margin of the headshield (ω) just inside the genal spine. Fixed cheek is thus very wide in front and very narrow behind; in profile almost flat except for the raised rim. Free cheeks smooth, gently raised in centre, falling to a broad deep furrow inside a raised rim. This rim is broader anteriorly, where it is continuous with the rim of the fixed cheek, becomes sharper and narrower posteriorly, and at genal angle passes into the librigenal spine. This spine is as long as the headshield, reaching to the posterior thoracic segment; broad and inflated, terminating in a blunt rounded extremity. The interior angle with the posterior margin of the headshield is rounded. Pleuroccipital furrow of free cheek faint and broad.

Thorax of eight segments; axial region strongly raised, separated from pleural regions by a sharp axial furrow. Axis one third width (tr.) of carapace at anterior, narrowing slightly posteriorly. Axial rings nearly parallel-sided (tr.) slightly embayed, posteriorly and bent forward anteriorly; articulating half-ring not visible. Pleural segments parallel-sided, slightly flexed backwards from a point close to axial furrow; extremities bluntly rounded. Pleural furrows faint; in median (ensag.) position near axial furrow, then directed obliquely backwards across segment, becoming effaced halfway along (tr.).

Pygidium sub-triangular, $1\frac{1}{2}$ times broader (tr.) than long (sag.): anterior margin strongly and evenly curved forward. Axis sharply raised, separated by a sharp axial furrow from the more moderately upcurved pleural regions. Axis tapers rapidly, terminating in a triangular point a short distance in front of the posterior of the pygidium. 8 or more axial rings, separated by strong, straight furrows. Pleural fields crossed by 6 furrows, becoming progressively weaker and more oblique towards the posterior. All pleural furrows die out at rim, which is moderately broad and slightly flattened. Postaxial region bent ventrally, no postaxial ridge.

Remarks. The genus *Diacoryphe* is almost unique among Carboniferous trilobites in showing posterior effacement of the glabella, and it is for this reason that the species *vandergrachtii* is consigned to this genus. It differs from the type species, *D. pfeifferi*, in the less widely expanded anterior part of the fixed cheek, on the long

palpebral lobes, and in the strong anterior border. It resembles *D. strenuispina* Osmólska in having a strong, inflated genal spine. The pygidium, with its strong segmentation, is more like that of a Phillipsiid, than that of *D. pfeifferi*. It seems likely that a new genus is needed for the reception of the British species.

III STRATIGRAPHICAL CONCLUSIONS

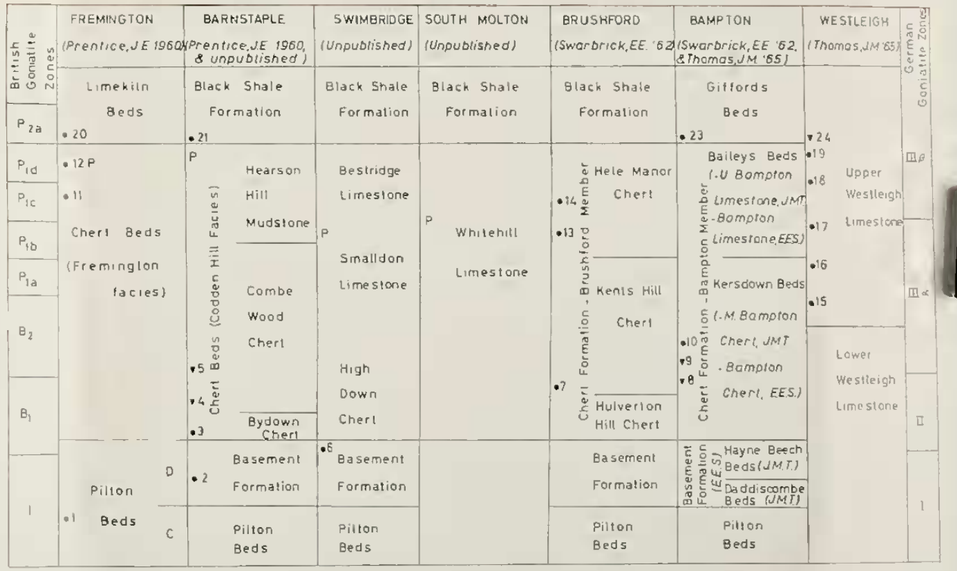
The trilobites described here occur mostly in a region of great structural and stratigraphical complexity, which has as yet been very incompletely unravelled. The diagram (Table 1) attempts to record the succession in various areas of North Devon, in so far as it has been resolved. With few exceptions the trilobites occur in a group of beds of distinctive pale grey or white colour, which occupies a median position in the Chert Formation. The Chert Formation is underlain by the Basement Beds, and these by the Pilton Beds. Goldring (1955), on goniatite and trilobite evidence has classified the top of the Pilton Beds with the *Protocanites* Zone (I) The occurrence of *Protocanites* cf. *lyoni*, probably in the Basement Formation (Prentice & Thomas 1965) indicates that the *Protocanites* Zone extends above the Pilton Beds. The occurrence of *Pericyclus* aff. *homoceratoides* at Swimbridge, also in beds which are probably Basement Formation, indicates that this formation also includes the base of zone II (Butcher & Hodson 1960). The top of the Chert Formation is in many places defined by the "*G. spiralis*" band, of P_1—P_2 age (Prentice 1960), indicating that this Formation extends throughout most of zones II and III of the German sequence.

Within this succession it seems possible to recognize five successive trilobite faunas. The lowest occurs near the base of the pale chert group, probably close above the Basement Formation, and, so far, has been found in only one place. It yields *Macrobole* aff. *laticampa*, which occurs in Zone I in Poland. The second is more widespread: it is the fauna described by the author (Prentice 1960) from Bed X in Park Gate Quarry, Tawstock. This bed is characterized by the occurrence of the genus *Spatulina*, whose only representative outside Devon occurs in Zone II of Germany (Richter, R. & E. 1949). Associated with this is *Liobole glabra* and *Macrobole* cf. *brevispina*. *Liobole glabra* also occurs at Warrenshill Quarry, Bampton, in white cherts referred by Thomas to the Kersdown Beds (Webby & Thomas 1965). These cherts lie immediately below similar beds with *Phillibole coddonensis*, which forms the chief element of the third trilobite fauna. This has been found in place also in Templeton Quarry, Tawstock (Bed Y, Prentice 1960). The occurrence of both the *Spatulina* fauna and the *P. coddonensis* fauna at various localities (Coombe Wood, Hannaford, Codden Hill) indicated by museum specimens, suggests that these two faunas are widespread and stratigraphically are closely superposed. *Phillibole aprathensis* is also recorded from these localities, but there is some evidence to suggest that it may occur in and characterise a higher horizon. For example, it occurs in a loose block above the beds exposed at Warrenshill Quarry, Bampton; and at a high horizon in cherts in the Chudleigh region. The highest fauna is that represented by *Phillipsia leei*, a species constantly found in the "*spirale* band" which marks a very widespread depositional change in south-west England.

Explanation of Table 1

Numbers in circles represent goniatite faunas, those in squares contain trilobites. The following list indicates only the latest reference to the fossils.

Goldring, R. 1955 Appendix : 48).	Pilton Beds.
Gastrioceras crassa Schmidt.	Tutshill farmyard.
Imitoceras sp.	
Imitoceras,	
2 Prentice, J. E. & Thomas, J. M. (1965 : 34).	
Prolecanites cf. *lyoni* Meek & Worthen.	Well near Mt. Sandford, Barnstaple.
3 Unpublished	
Goniatites ? pericyclids.	Bydown Quarry, Swimbridge.
4 Prentice, J. E. 1960 : 271).	Park Gate Quarry, Tawstock.
Ammonellipsites Kayseri (H. Schmidt)	
Ammonellipsites cf. *kochi* (Holzapfel).	
Liobole glabra R. & E. Richter.	
Spirolites spatulata Woodward (as *Ph.* ? (*Cy.*) *spatulata*).	
Sphaerospira sp. n. (as *Ph.* ? (*Cy.*) sp. nov.)	
Cyrtosymbole (*Macrobole*) cf. *brevispina* Osmólska (as *Cyrtosymbole* (*Waribole*) cf. *aequalis*).	
5 Prentice, J. E. 1960 : 272).	Templeton Quarry, Tawstock.
Phillibole coddonensis Woodward.	
6 Butcher, N. E. & Hodson, F. (1960 : 76).	Railway Cutting, Swimbridge
Pericyclus ? *Rotopericyclus* aff. *homoceratoides* Schmidt-Kaler.	
7 Swarbrick, E. E. unpublished.	Kents Hill Quarry, Dulverton.
Imitoceras aff. *ornatissimus* (de Koninck).	
8 9. Webby, B. & Thomas, J. M. (1965) and the present paper	
Liobole glabra R. & E. Richter	Bed 15, Warrenshill Quarry, Bampton.
Phillibole coddonensis Woodward	Beds 16 & 18, Warrenshill Quarry, Bampton.
Typhloprolecanites cephalisprina sp. nov.	Bed 18, Warrenshill Quarry, Bampton.
10. Webby, B. & Thomas, J. M. 1965.	
Bollandites sp.	Kersdown Quarry, Bampton.
11–14. Butcher, N. E. & Hodson, F. (1960 : 77).	
11. *Goniatites sphaericostriatus* Bisat	Fremington.
12. *Girtyoceras burhennei* (Schmidt)	Fremington.
13. *Goniatites falcatus* Roemer	Hele Quarries, Dulverton.
14. *Goniatites* of the *concentricus/striatus* group	Hele Quarries, Dulverton.
15–19. Prentice, J. E. & Thomas, J. M. (1960 : 6, 7).	
15. *Goniatites hudsoni—antiquatus* group	Westleigh Quarries.
16. *Goniatites crenistria* Phillips	Westleigh Quarries.
17. *Goniatites falcatus* Roemer	Westleigh Quarries.
18. *Hibernicoceras carraunense* Moore & Hodson *Sudeticeras crenistriatus* Bisat	Westleigh Quarries.
19. *Neoglyphioceras spirale* (Phillips) *Sudeticeras splendens* (Bisat)	Westleigh Quarries.
20 & 21. Prentice, J. E. (1960 : 275).	
Neoglyphioceras spirale (Phillips)	Fremington Pill, and Tawstock.
cf. *Mesoglyphioceras granosum* (Portlock)	Fremington Pill, and Tawstock.
22. This paper (p. 212). *Phillipsia leei* Woodward.	Hole Lake Farm Quarry, Bampton.
23. Prentice, J. E. & Thomas, J. M. (1960 : 7).	
Neoglyphioceras spirale (Phillips).	Above Bampton Limestones.
cf. *Mesoglyphioceras granosum* (Portlock)	
Dimorphoceras kathleeni Moore	
Sudeticeras splendens (Bisat)	
24. This paper (p.212).	
Neoglyphioceras spirale Phillips	Whipcott Quarry, Westleigh.
Phillipsia leei Woodward	Whipcott Quarry, Westleigh.



• 20 - Goniatite horizon ▾4 - Trilobite horizon P - Posidonia

That the species may have entered the area prior to this is indicated by its occurrence in white chert at Ideford, Devon, and in the upper part of the Bailey's Beds (Thomas 1962) at Bampton.

The correlation of these faunas with their contemporaries in the rest of the British Isles and in northern Europe presents some problems. The *M.* aff. *laticampa* locality is within 2 kilometres of the railway-cutting from which *Pericyclus* aff. *homoceratoides* is recorded by Butcher & Hodson (1960 : 76) and the latter horizon may not be very far below the base of the Chert Formation. Nevertheless this must mean that the Chert Formation begins in zone II, and a solid, but decayed, pericyclid found with *M.* aff. *laticampa* supports this correlation. The *Spatulina* fauna has been equated (Prentice 1960) with the top of zone II, a correlation confirmed by the occurrence of *M.* cf. *brevispina*. There is no doubt that this is succeeded immediately by the *Phillibole coddonensis* fauna. *P. coddonensis* is closely related to *Phillibole culmica* R. & E. Richter, and with *Ph. aprathensis* is known only from the Zone IIIβ of Germany. It seems almost certain that in the British Isles these two species extend down into the equivalents of Zone IIIα. At Warrenshill Quarry, Bampton *P. coddonensis* is found, less than a foot above a bed with *Liobole glabra*, with no sign of a stratigraphical break between. In the Brushford area, the pale cherts (Kents Hill Chert) are succeeded by beds containing $P_{1\beta}$ (i.e. Zone IIIα) goniatites (Butcher & Hodson 1960). In the north of England a form related to *P. aprathensis* characterized the B_2 zone (Calver & Ramsbottom 1962), which certainly lies below the $P_{1\alpha}$ (IIIα) zone, and which includes in its fauna *Entogonites grimmeri* Kittle, whose type material comes from Zone IIδ in Sauerland (Schmidt 1942 : 49). The occurrence of *Bollandites* cf. *castletonense*, in the Kersdown Beds (Thomas 1962) a typical B_2 zone form in the north of England, further links these *Phillibole* faunas with zones B_2 and IIIα.

The age of the *Phillipsia leei* fauna is less equivocal, as it is associated with the " *spiralis* band " lying at the P_1—P_2 junction, or in the sub-zone of $III_{\beta 7}$ (see above and Prentice 1960). The finding of a specimen of this species at a precisely similar horizon in Sauerland suggests that the fauna may be of zonal significance.

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